The feeder stream: investigating the mechanisms causing precipitation in cyclones

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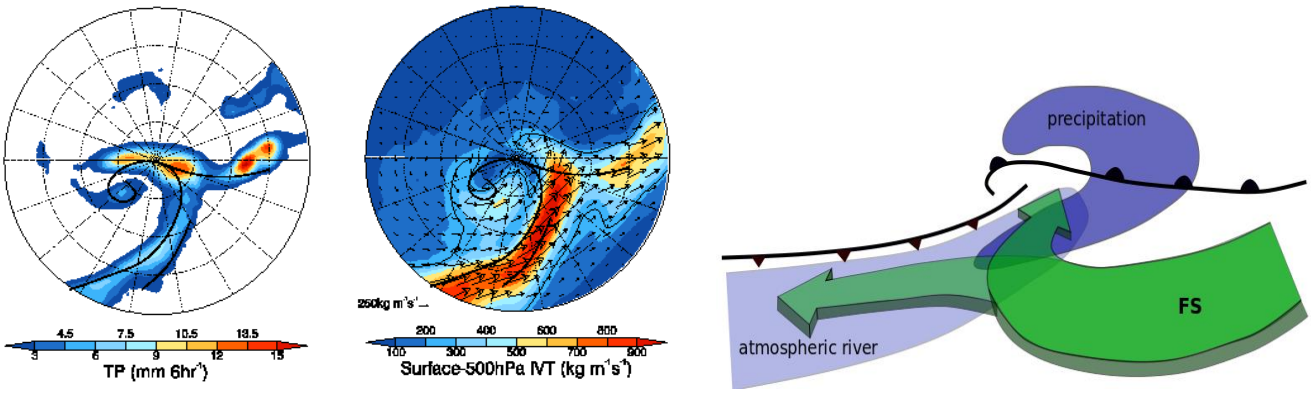
Flooding events in Europe can cause huge economic losses, damage to infrastructure and fatalities. A good understanding of the physical processes that generate precipitation is important for forecasting precipitation and assessing the risk of subsequent flooding. However, there is currently an open scientific debate regarding the mechanisms responsible for generating extreme rainfall and flooding.

Studies have shown that many flooding events in the UK are associated with low-level filaments of condensed water vapour within mid-latitude cyclones. These filaments are known as atmospheric rivers. Atmospheric rivers are thought to be rivers of moisture that transport moisture from the subtropics towards the centre fo cyclones, where it then precipitates out when it encounters orography. However, at Reading University, we have identified a new mechanism by which cyclones transport moisture. Recent research has shown that the precipitation is linked to an airflow known as the 'feeder-stream'. The feeder-stream transports moisture from the environment ahead of the cyclone towards the cyclone centre at low-levels. This research demonstrates, in a limited set of mid-latitude cyclones, that moisture in the environment local to the cyclone dominates the supply of moisture to the cyclone and drives both local precipitation and the formation of the atmospheric river. In this project we will expand this analysis to examine the feeder-stream mechanism in a wide range of mid-latitude cyclones to test this new hypothesis further.

The second part of the project will focus on land-falling mid-latitude cyclones in order to understand how the feeder-stream interacts with orography to generate heavy precipitation. We hypothesise that extreme precipitation totals are frequently generated in the UK when precipitation falling from a mid-latitude cyclone's upper-level cloud falls through the lower-level orographic cloud capping a hill. When this occurs, precipitation over the hill can intensify rapidly. The PhD student will work with members of the Environment Prediction group and the Global Model Evaluation and Development group at the Met Office to examine a wide range of case studies to investigate how the feeder stream interacts with orography and to quantify how high intensity precipitation leads to flooding.



Cumbrian Floods 2009. Left: 6-hourly accumulated precipitation (TP) showing precipitation along fronts (black). Middle: Vertically integrated vapour transport (IVT) magnitude and vectors showing position of atmospheric river (IVT > 250 kg $m^{-1}s^{-1}$). Right: Schematic of the feeder stream (FS) airflow as it transports moisture towards the cold front where it converges to form the atmospheric river and ascends to form precipitation.

Training opportunities:
The student will visit the Met Office at least twice during the project to discuss the design and implementation of experiments using the Met Office Environmental Prediction system.

Student profile:
This project will be suitable for students with a degree or extensive experience in mathematics or physics or a closely related physical or environmental science. Students should have a strong interest in high impact weather events and the interpretation and numerical modelling of weather processes.

Funding particulars:
This project may be CASE funded by the Met Office.

References: (optional)

Dacre, H.F., Clark, P.A., Martinez-Alvarado, O., Stringer, M.A. and Lavers, D.A., 2015. How do atmospheric rivers form? *Bulletin of the American Meteorological Society*, *96*(8), pp.1243-1255.

http://www.reading.ac.uk/nercdtp